FLOOD INSURANCE STUDY

CITY OF BANDERA, TEXAS
BANDERA COUNTY

REVISED
JULY 17, 1989

Federal Emergency Management Agency

COMMUNITY NUMBER - 480021

NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program (NFIP) have established repositories of flood hazard data for floodplain management and flood insurance study purposes. This Flood Insurance Study (FIS) may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study revises and updates a previous Flood Insurance Study/Flood Insurance Rate Map for the City of Bandera, Bandera County, Texas. This information will be used by the City of Bandera to update existing floodplain regulations as part of the Regular Phase of the National Flood Insurance Program (NFIP). The information will also be used by local and regional planners to further promote sound land use and floodplain development.

In some states or communities, floodplain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the state (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for the study effective on October 13, 1981, represent a revision of the original analyses prepared by Black & Veatch, Inc., Consulting Engineers for the Federal Emergency Management Agency (FEMA), under Contract No. H-3814. That work was completed in November 1976.

For the revision effective on July 17, 1989, updated hydrologic and hydraulic analyses for the Medina River were prepared by the Fort Worth District of the U. S. Army Corps of Engineers (COE) for FEMA. This work was completed in January 1988.

1.3 Coordination

On February 2 and 4, 1976, an initial Consultation and Coordination Officer's (CCO) meeting was held with representatives of FEMA, the city, and Black & Veatch, Inc., (the study contractor) to identify the streams to be studied by detailed methods. The Texas State Highway Department provided bridge information for use in hydraulic calculations. The Texas Water Development Board (TWDB) provided U. S. Geological Survey (USGS) flood-prone area maps, background information and assistance in locating sources of data for use in the study. Hydrologic analyses and flood profiles for the streams studied were coordinated with those developed concurrently by Black & Veatch, Inc., for the Flood Insurance Study for the unincorporated areas of Bandera County.

Further coordination for this study included meetings with city officials on July 13, 1976, for the purpose of data collection and on September 14, 1976, to discuss procedures and progress.

On November 30, 1976, a final CCO meeting was held with representatives of FEMA, the city, and the study contractor to review the results of the original study.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated area of the City of Bandera, Bandera County, Texas. The area of study is shown on the Vicinity Map (Figure 1).

The Medina River was studied by detailed methods from a point approximately 0.6 mile downstream of Fifteenth Street to a point approximately 0.4 mile upstream of Sixth Street Extension. The July 17, 1989 revision incorporates updated analyses for the entire length of the Medina River within the community. The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development and proposed construction.

The remaining portion of the Medina River was studied by approximate methods. Approximate analyses were used to study those areas having a low development potential or minimal flood hazards.

2.2 Community Description

The City of Bandera is located in central Bandera County approximately 45 miles northwest of San Antonio. It is completely surrounded by the unincorporated areas of Bandera County. Primary transportation routes through the city include State Routes 16 and 173.

Bandera is the county seat of Bandera County and a local trade center. It is also a center for recreational and vacation activities. The population of the city in 1970 was 891 (Reference 1).

Most commercial development in the city is located in the central business district and along State Routes 16 and 173. Most residential development is located on high ground in the central and northeastern part of the city. Scattered residential development has occurred in floodplain areas, particularly along the banks of the Medina River.

The Medina River flows in a southeastern direction through Bandera County and forms the southern and western boundaries of the city. Dry Hollow Creek originates within the city and flows in a southern direction through the central business district to its confluence with the Medina River. Topography within the city is gently rolling with elevations ranging from approximately 1,190 to 1,275 feet

However, the Medina River watershed includes very rugged terrain with steep ridges and hills extending to elevations above 2,200 feet. Much of the countryside is rangeland and is grass- or wood-

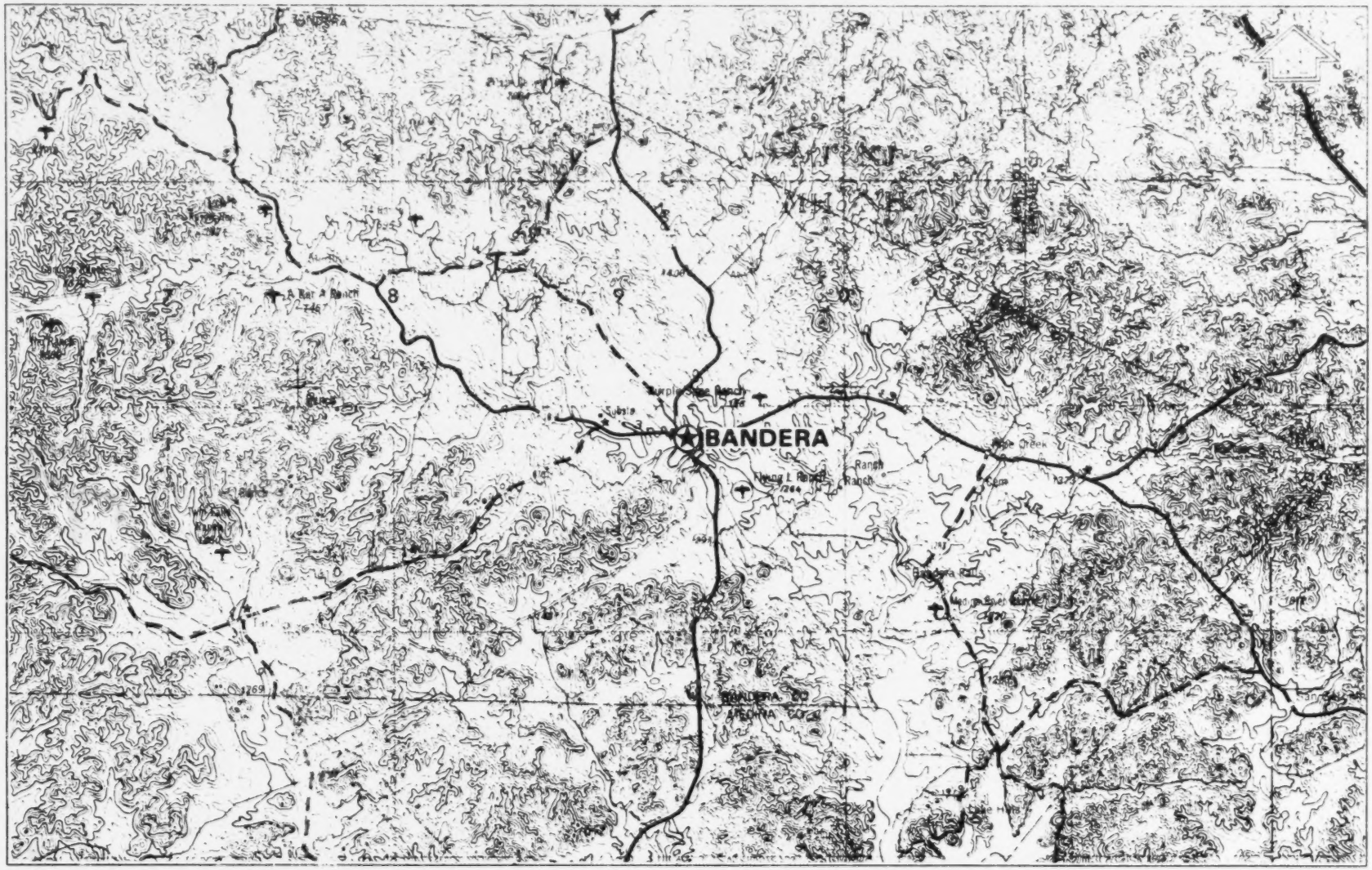


FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BANDERA, TX

(BANDERA CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

covered. Annual average rainfall is approximately 28 inches and mean temperatures range between approximately 50 and 85 degrees Fahrenheit (^{o}F) (Reference 2). Except in the floodplains, the soil is shallow and rocky with low permeability and high runoff potential.

2.3 Principal Flood Problems

The Medina River is the primary flood threat to Bandera due to the large drainage area above the city (approximately 330 square miles) and the high runoff potential. Dry Hollow Creek is responsible for short-term local flooding.

The City of Bandera has experienced several major floods from the Medina River. The earliest recorded large flood occurred in 1853, but there is insufficient data for an estimate of its recurrence interval. Floods also occurred in 1870, 1900, 1901, 1903, 1917, 1918, 1919, 1921, and 1936. The flood of record took place in 1978; with an estimated peak discharge of 285,000 cubic feet per second (cfs), the flood had a recurrence interval which was slightly greater than 500 years. The Fort Worth District COE established high-water marks for this flood at three locations: at State Route 173, at a point approximately 0.82 mile downstream of the Sixth Street Extension, and at a point approximately 0.32 mile upstream of the Sixth Street Extension. The second-largest flood on record is the flood of 1900, which was produced by rainfall varying from 24 to 31 inches over the watershed. During the 1900 flood, according to local residents, the Medina River crossed the watershed divide at the north side of Bandera to Dry Hollow Creek and flowed through the center of town causing much damage. Flood water was also reported to have been 10-15 feet deep in the southwest or "Loop" area of Bandera.

Two low-water bridges crossing the Medina River within the city re overtopped regularly by high water and traffic using State Routes 16 and 173 is interrupted periodically by floodwaters from the Medina River or its tributaries. Records are not available for documenting flood damage losses.

Two streamflow gages established by the USGS are in the vicinity of the City of Bandera. The first, now discontinued, was located approximately 500 feet upstream of Bandera Falls and 0.6 miles upstream of Red Bluff Creek. The drainage area for this gage is approximately 474 square miles and has a period of record from 1923 to 1982. The second gage is located approximately 1.9 miles upstream of Bandera Creek and 5.6 miles downstream of Indian Creek, approximately 40 feet downstream of the centerline of State Route 173. Its drainage area is approximately 330 square miles and has a period of record from 1982 to present.

2.4 Flood Protection Measures

A strip park along the north bank of the Medina River extends from Main Street to First Street and serves to minimize flood damages from low frequency flooding. However, much of the city remains

susceptible to damage from major floods. A channel dam is located on the Medina River approximately 0.71 mile upstream of Bandera's lower corporate limits. No other flood control measures are presently in effect or planned.

3.0 ENGINEERING METHODS

For the flooding source studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for floodplain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for the flooding source studied in detail affecting the community.

Peak discharges for the Medina River were determined by using the Flood Flow Frequency Analysis computer program developed by the COE. The guidelines for calculating the flood flow frequency are outlined in the USGS Bulletin 17B and a report entitled Generalized Skew Coefficients of Annual Maximum Streamflow Logarithms in Southwestern Division, Corps of Engineers (References 3 and 4).

A summary of the drainage area-peak discharge relationships for the Medina River is shown in Table 1, "Summary of Discharges."

TABLE 1 - SUMMARY OF DISCHARGES

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (sq. miles)	PEAK DISCHARGES (cfs) 10-YEAR	50-YEAR	100-YEAR	500-YEAR
MEDINA RIVER					
At the downstream corporate limits	330	42,300	106,000	144,000	265,000

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the source studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

Cross sections were developed from field surveys and topographic maps at a scale of 1:24,000 with a contour interval of 20 feet (Reference 5). The cross sections were located at close intervals above and below bridges and culverts in order to compute the backwater effects of these structures. All bridges, dams, and culverts were field surveyed to obtain elevation data and structural geometry.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross-section locations are also shown on the Flood Insurance Rate Map (Exhibit 2).

Water-surface elevations of floods of the selected recurrence intervals were computed using the COE HEC-2 step-backwater computer program (Reference 6). The HEC-2 model was calibrated to a USGS gage rating curve based on data collected at State Route 173, and to the high-water marks from the 1978 flood. Flood profiles were drawn showing computed water-surface elevations for floods of the selected recurrence intervals. The starting water-surface elevations were obtain through the use of the slope/area method.

Channel roughness coefficients (Manning's "n") used in the hydraulic computations were assigned based on field inspection of floodplain and channel areas, and calibration of the HEC-2 model to historical flooding events. The channel "n" values for the Medina River ranged from 0.040 to 0.055 and the overbank "n" values ranged from 0.040 to 0.070.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps; the descriptions of the marks are presented in Elevation Reference Marks (Exhibit 3).

4.0 FLOODPLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound floodplain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100- and 500-year floodplain boundaries and 100-year floodway to assist in developing floodplain management measures.

4.1 Floodplain Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for floodplain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For the stream studied in detail, the 100- and 500-year floodplain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:24,000 with a contour interval of 20 feet (Reference 5).

For the stream studied by approximate methods, the 100-year floodplain boundaries were delineated using USGS topographic maps (Reference 5).

The 100- and 500-year floodplain boundaries are shown on the Flood Insurance Rate Map (Exhibit 2). On this map, the 100-year floodplain boundary corresponds to the boundary of the areas of special flood hazards (Zone AE), and the 500-year floodplain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year floodplain boundaries are close together, only the 100-year floodplain boundary has been shown. Small areas within the floodplain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on floodplains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of floodplain management involves balancing the economic gain from floodplain development against the resulting increase in flood hazard. For purposes of the National Flood Insurance Program, a floodway is used as a tool to assist local communities in this aspect of floodplain management. Under this concept, the area of the 100-year floodplain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent floodplain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodway in this study is presented to local agencies as a minimum standard that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodway presented in this study was computed for certain stream segments on the basis of equal conveyance reduction from each side of the floodplain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 2). The computed floodway is shown on the Flood Insurance Rate Map (Exhibit 2). In cases where the floodway

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH[2] (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Medina River								
A	15,550	775/80	16,579	8.7	1,219.9	1,219.9	1,220.6	0.7
B	18,110	1100/755	21,292	6.8	1,225.2	1,225.2	1,225.9	0.7
C	19,610	825/380	15,338	9.4	1,226.4	1,226.4	1,227.3	0.9
D	22,290	700/300	13,958	10.3	1,231.8	1,231.8	1,232.3	0.5
E	25,900	1404/1000	16,123	8.9	1,237.5	1,237.5	1,237.7	0.2
F	28,250	650/355	11,959	12.0	1,243.1	1,243.1	1,243.6	0.5
G	30,290	2145/250	28,369	5.1	1,249.9	1,249.9	1,250.5	0.6
H	32,480	2520/180	30,842	4.7	1,252.4	1,252.4	1,253.2	0.8

[1]Feet above confluence of Julian Creek
[2]Width/width within corporate limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

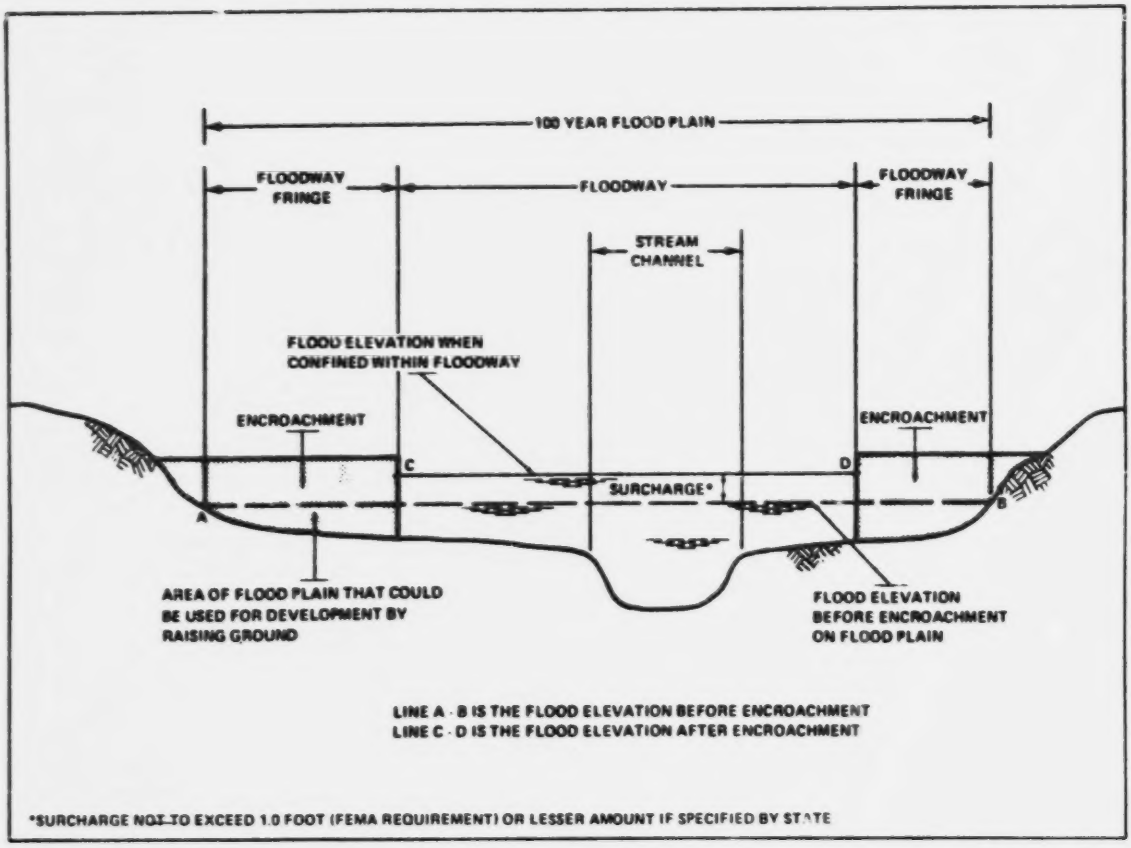
CITY OF BANDERA, TX
(BANDERA CO.)

FLOODWAY DATA

MEDINA RIVER

and 100-year floodplain boundaries are either close together or collinear, only the floodway boundary is shown. Portions of the floodway widths for the Medina River extend beyond the corporate limits.

The area between the floodway and 100-year floodplain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the floodplain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to floodplain development are shown in Figure 2.


100 YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE A - B IS THE FLOOD ELEVATION BEFORE ENCROACHMENT
LINE C - D IS THE FLOOD ELEVATION AFTER ENCROACHMENT
*SURCHARGE NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE

FLOODWAY SCHEMATIC Figure 2

5.0 INSURANCE APPLICATIONS

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. The zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year floodplains that are determined in the Flood Insurance Study by detailed methods. In most instances, whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AH

Zone AH is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually areas of ponding) where average depths are between 1 and 3 feet. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone AO

Zone AO is the flood insurance rate zone that corresponds to the areas of 100-year shallow flooding (usually sheet flow on sloping terrain) where average depths are between 1 and 3 feet. Average whole-depths derived from the detailed hydraulic analyses are shown within this zone.

Zone A99

Zone A99 is the flood insurance rate zone that corresponds to areas of the 100-year floodplain that will be protected by a Federal flood protection system where construction has reached specified statutory milestones. No base flood elevations or depths are shown within this zone.

Zone V

Zone V is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Because approximate hydraulic analyses are performed for such areas, no base flood elevations are shown within this zone.

Zone VE

Zone VE is the flood insurance rate zone that corresponds to the 100-year coastal floodplains that have additional hazards associated with storm waves. Whole-foot base flood elevations derived from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year floodplain, areas within the 500-year floodplain, and to areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

Zone D

Zone D is the flood insurance rate zone that corresponds to unstudied areas where flood hazards are undetermined, but possible.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and floodplain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year floodplains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For floodplain management applications, the map shows by tints, screens, and symbols, the 100- and 500-year floodplains. Floodways and the locations of selected cross sections used in the hydraulic analyses and floodway computations are shown where applicable.

7.0 OTHER STUDIES

A Flood Insurance Study has been prepared for the unincorporated areas of Bandera County (Reference 7). The results of this study are in complete agreement with the results of that study.

Due to its more up-to-date nature, this study supersedes the previous Flood Insurance Study for the City of Bandera (Reference 8).

8.0 LOCATION OF DATA

Information concerning the pertinent data used in preparation of this study can be obtained by contacting FEMA, the Natural and Technological Hazards Division, Federal Regional Center, 800 North Loop 288, Denton, Texas 76201-3698.

9.0 BIBLIOGRAPHY AND REFERENCES

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2. U. S. Department of Commerce, Weather Bureau, Climatic Summary of the United States, Supplement for 1951 through 1960, Texas, 1965.

3. U. S. Department of the Interior, Geological Survey, Office of Water Data Collection, Interagency Advisory Committee on Water Data, "Guidelines for Determining Flood Flow Frequency," Bulletin 17B, Reston, Virginia, Revised September 1981.

4. University of Texas, Center for Research in Water Resources, Generalized Skew Coefficients of Annual Maximum Streamflow Logarithms in Southwestern Division, Corps of Engineers, Austin, Texas.

5. U. S. Department of the Interior, Geological Survey, 7.5-Minute Series Topographic Maps, Scale 1:24,000, Contour Interval 20 Feet: Bandera, Texas, 1964.

6. U. S. Army Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Generalized Computer Program, Davis, California, April 1984.

7. Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, Unincorporated Areas of Bandera County, Texas, Washington, D. C., November 1, 1981.

8 Federal Emergency Management Agency, Federal Insurance Administration, Flood Insurance Study, City of Bandera, Bandera County, Texas, Washington, D. C., October 13, 1981.

EXHIBIT 3 - ELEVATION REFERENCE MARKS

Reference Mark	Elevation (Feet NGVD)	Description of Location
RM 1	1,258.17	USGS disk stamped 1265 SA 19 set vertically in southwest wall of Bandera County Courthouse, approximately 2.5 feet northwest of south corner.
RM 2	1,219.45	Chiseled square on northwest corner of concrete bridge deck at State Route 173 crossing the Medina River, located on west side of metal guard rail.
RM 3	1,222.63	Boat spike in south side of power pole on northwest corner of Ninth Street and Maple Street.
RM 4	1,227.84	Boat spike in south side of power pole at northwest corner of Maple Street and Third Street, approximately 10 inches above ground.
RM 5	1,206.10	Chiseled square on top of east concrete curb in center of low water crossing at First Street and the Medina River.
RM 6	1,233.51	Boat spike in east side of power pole on southwest corner of Cypress Street and First Street.
RM 7	1,236.06	Boat spike in east side of power pole on southwest corner of First Street and Pecan Street.
RM 8	1,257.54	Boat spike on east side of power pole on southwest corner of Sixth Street and Pecan Street.
RM 9	1,218.89	Chiseled square on southeast corner of low water crossing at Sixth Street extension and Medina River.
RM 10	1,215.68	Boat spike in power pole on northeast corner of Fifteenth Street and Maple Street.

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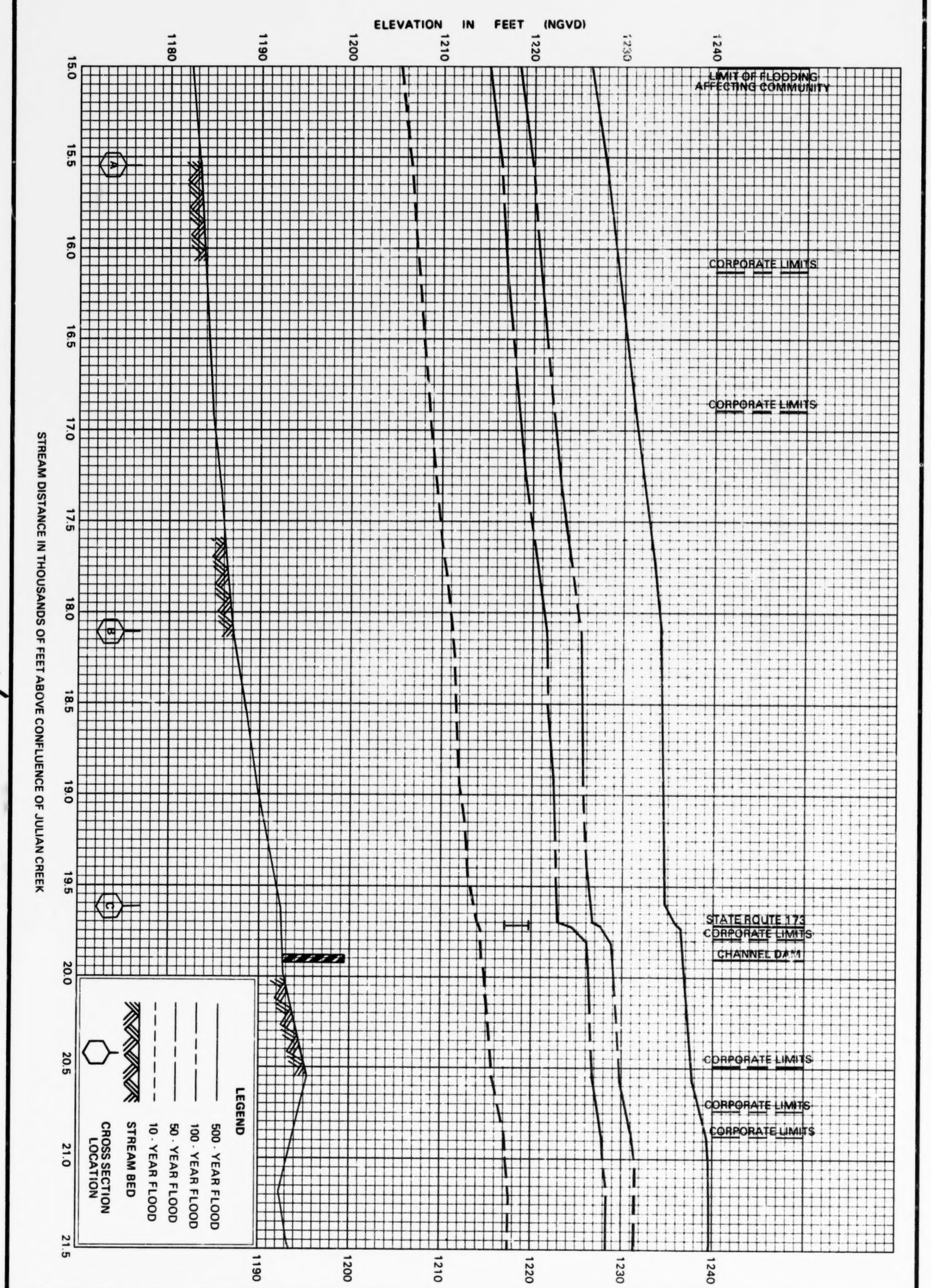

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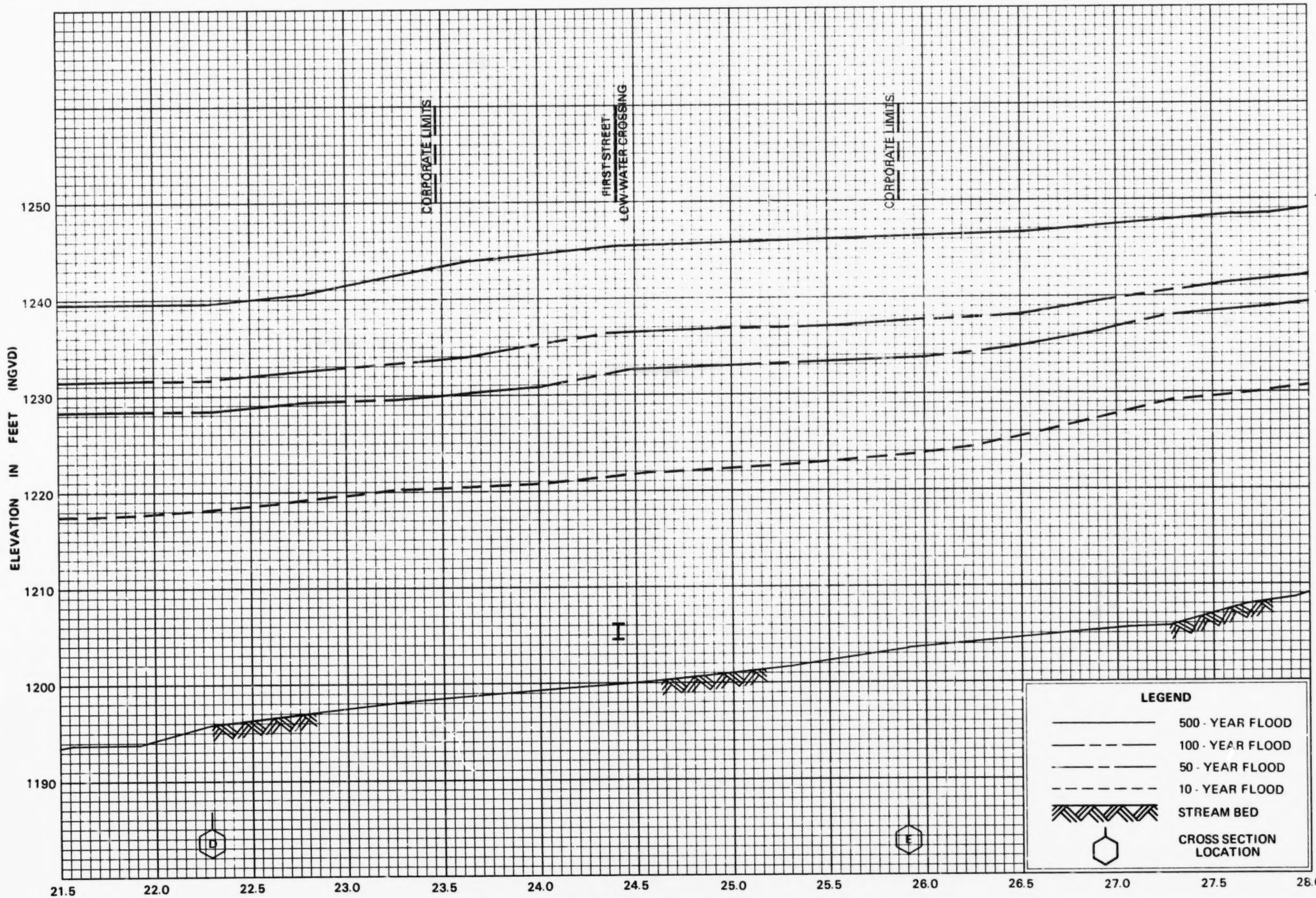
FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BANDERA, TX

(BANDERA CO.)

FLOOD PROFILES

MEDINA RIVER



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FLOOD PROFILES

MEDINA RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BANDERA, TX
(BANDERA CO.)

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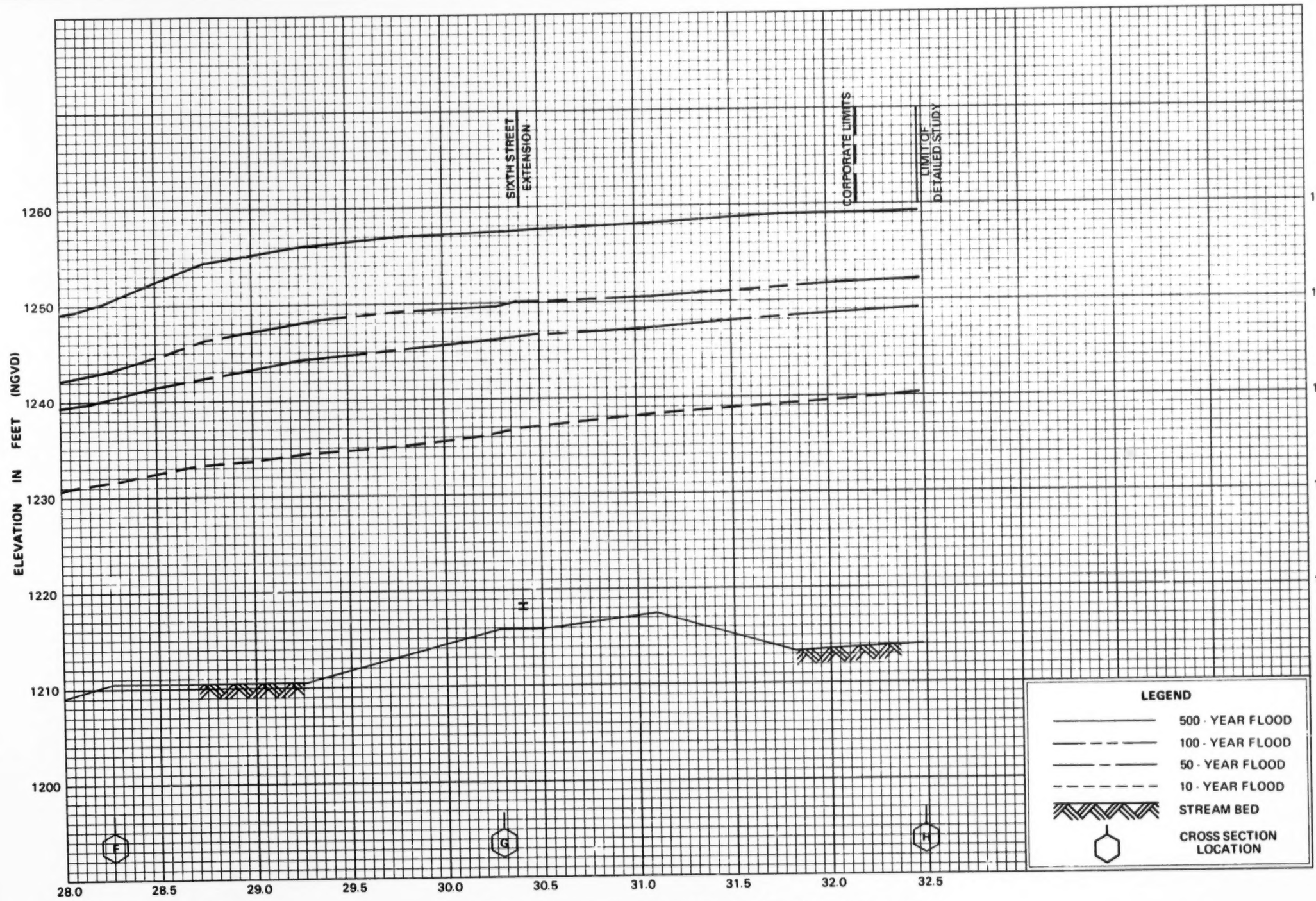

FLOOD PROFILES

MEDINA RIVER

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